

**Final Report**  
**2005 SPD Summer School on Helioseismology at HAO/NCAR**  
**Boulder, Colorado, July 24 - July 29, 2005**  
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## **I. Overview**

With the support provided by this NASA/LWS grant, as well as the grant from the NSF/ATM, the High Altitude Observatory (HAO) and the Advanced Study Program (ASP) of the National Center for Atmospheric Research (NCAR) successfully hosted the first summer school of the Solar Physics Division (SPD) of the American Astronomical Society (AAS), during the period July 24 - July 29, 2005, at the Foothills laboratories of NCAR. The one-week-long summer school provided an in-depth introduction of the theory, methods, and modern observations of helioseismology to physics graduate students and post-graduate early career scientists. A detailed description of the summer school can be found on the world wide web at <http://www.hao.ucar.edu/summerschool/>.

## **II. Participants**

A total of 17 lecturers, who are world recognized experts in the field of helioseismology and stellar interior physics, came to to teach at the summer school. They are:

Aaron Birch (CoRA/NWRA, USA)  
Tom Bogdan (HAO/NCAR, USA)  
Doug Braun (CoRA/NWRA, USA)  
Tim Brown (HAO/NCAR, USA)  
Jørgen Christensen-Dalsgaard (Aarhus University, Denmark)  
Mausumi Dikpati (HAO/NCAR, USA)  
Peter Gilman (HAO/NCAR, USA)  
Brad Hindman (JILA/University of Colorado at Boulder, USA)  
Alexander Kosovichev (Stanford University, USA)  
John Leibacher (NSO, USA)  
Travis Metcalfe (HAO/NCAR, USA)  
Mark Miesch (HAO/NCAR, USA)  
Mark Rast (HAO/NCAR, USA)  
Markus Roth (KIS, Germany)  
Michael Thompson (The University of Sheffield, UK)  
Juri Toomre (JILA/University of Colorado at Boulder, USA)  
Junwei Zhao (Stanford University, California, USA)

Most of these lecturers stayed at the summer school during the entire one-week period of the program, participating in all school activities and interacting with the students.

The summer school had a total of 33 students, of which 20 are from US universities, 13 are from abroad, 25 are graduate students, 6 are postdoctoral researchers, and 2 are teaching faculty from a US college. There are 12 female students. There were no tuition and fees for the summer school. All of the students, except those that are Boulder residents (4), the 2 college faculty, and 2 students from the Max Planck Institute for Solar System Research,

Germany, (who are fully supported by their supervisor at their home institution), received full or partial financial support to pay for their travel and/or local living expenses (lodging, meals, ground transportation).

### **III. Description of the summer school program**

The summer school curriculum consisted of 19 lectures and 3 hands-on lab exercises. The lectures covered the following fundamental topics in solar interior theory and helioseismology:

- The solar internal structure and evolution
- An overview of solar convection
- An overview of the solar cycle and the solar dynamo
- Observing waves on the Sun and other stars
- Fluid motions and MHD in the solar convection zone and the Tachocline
- Theory of solar and stellar oscillations
- Inferring solar internal structure and rotation from p-mode frequencies and frequency splittings
- Time-distance helioseismology
- Ring diagram analysis
- Helioseismic holography
- Probing sunspots and impact on space weather
- Computational Asteroseismology.

The 3 hands-on exercises are:

- Computing power spectra from MDI and GONG data cubes
- Hands-on exercise with time-distance helioseismology
- Hands-on experiments with inversion.

These exercises are carefully designed by the lecturers that gave students an opportunity to directly put what they have learned into practice. They allowed the students to directly interact with real helioseismology data, both ground based (GONG) and from space (MDI/SOHO), and solve a set of problems by applying the helioseismic data reduction and analysis methods they have learned. The students found these exercises very useful and engaging. During the course of the labs, there were a lot of student-student and student-instructor discussions. In several cases, the students not only solved the assigned problems but also went on to make independent original analysis and finding new interesting things from the data.

All of the lecture viewgraphs, notes, and lab exercise materials are put on line and can be downloaded from the summer school web-site given above.

The summer school also had several social events including an ice-breaker reception dinner at the scenic Tree Plaza of the NCAR Mesa Lab, a volleyball game in the middle of the summer school week, and a final reception at the end of the summer school.

### **IV. Student feedback**

At the end of the summer school, students are asked to fill out a student appraisal to evaluate on the overall course, the lectures, the hands-on lab exercises, and the logistics of the summer school.

On the organization, duration, breadth, and content of the course as a whole, the summer school got overall very positive remarks. Several common comments for improvement are: the course is a bit too intense; needs more hands-on exercises and more discussion sessions.

On the question of how effective are the lectures in helping to learn the subject, on a scale of 1-5 (from least effective to most effective), the students gave scores ranging from 3 to 5, with an average of 3.9. On the question of whether the lectures are easy to understand, on a scale of 1-5 (from incomprehensible to very easy to understand), the students gave scores ranging from 3 to 4, with an average of 3.5. On the level of mathematics being presented in the lectures, 71% of the students said the level was just right, 18% said that it was too complicated, and 11% said that it was in-sufficient. On the question of what aspects of the lectures the students find most helpful, many students mentioned “the overview and the basic introductory parts of the lectures”, “starting out from a basic level and gradually build up in complexity”, “the use of movies, visualizations combined with equations”, “the connection between theory and observations”. On the question of what aspects of the lectures the students find least helpful and need to be changed, a common comment by the students was that some of the lectures were too much like conference talks and focused too much on the lecturers’ own research.

On the questions of how helpful the hands-on exercises are, on a scale of 1-5 (from least helpful to most helpful), the students gave scores ranging from 2 to 5 with an average of 4.2. The students responded overwhelmingly positively to these exercises and suggested that there should be more of them and each lab should be given more time (than 1.5 hours).

The students all gave very positive remarks on the support provided by the HAO LOC before and during the school. On lodging and local transportation, the students commented that the bus pick-up from the hotel was too early in the morning, and that the hotel accommodation was very nice but its location is too far away from Boulder downtown.

#### **IV. Budget**

Most of the NASA/LWS funding was used for student financial support. The remainder was used on purchasing material and supplies for the school.